

# North America

For many decades, North America has led the world with the breadth and depth of its science, and its continued dominance is apparent in the Nature Index results.

ARTICLE COUNT (AC): 29,325  
 FRACTIONAL COUNT (FC): 22,276  
 WEIGHTED FRACTIONAL COUNT (WFC): 20,126

North America is striding ahead of all other regions, including its nearest rival North and Western Europe, in producing high-quality science. Boasting a WFC of more than 20,000 in the Nature Index, its two constituent countries, Canada and the United States, have long enjoyed strong support for natural science, mostly from their research universities. But both are adapting to significant shifts in public funding in recent years. The United States, comfortably the global leader in the index, is weathering funding cuts that have curtailed many research agencies. Canada, which comes in seventh globally and has notable strengths in life sciences and earth and environmental sciences, is attempting to tie its research more tightly to commercial innovation.

The United States dwarfs its northern neighbour on nearly every measure, but the index reveals more nuanced information about how it uses its resources. For example, according to UNESCO, there are 1.25 million researchers employed in the United States, which is 3,979 per million citizens; Canada has only 157,000 researchers, but this translates to 4,563 per million people — a higher density. The Nature Index, however, shows that the United States is better able to leverage its researchers, producing a WFC of 14.9 per thousand researchers compared to Canada's 9.4 (see 'Researcher efficiency').

Researcher efficiency may be a factor in the relative lack of collaboration with countries outside the region, a metric that is lower than the global average across all subjects. The United States is relatively self-sufficient, particularly when it comes to papers in either *Nature* or *Science* (see 'Collaboration rate').

**“CHINA, OF COURSE, IS NOT THE ONLY NATION RAMPING UP R&D WHILE WE REST ON OUR LAURELS.”**

The region shows an above-average contribution to the life sciences, which accounts for nearly half of its output (see 'Research strengths'). For the United States, that focus has historically been encouraged by funding from the government's medical research agency, the National Institutes of Health (NIH) — whose budget, however, is shrinking — in real terms, it is now four-fifths of its value a decade ago (National Institutes of Health). Its Canadian counterpart, the Canadian Institutes of Health Research, also has seen its purchasing power wane in recent years.

## UNITED STATES: SEEKING STABLE GROWTH

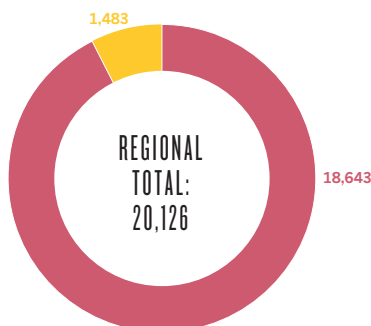
The United States' WFC in the Nature Index is 18,643, more than triple that achieved by second-place and ascendant challenger China. But maintaining this supremacy might prove difficult: 2013 budgets for many US research agencies were flat. The prospect of prolonged federal funding constraints gravely worries many in the research community. "China, of course, is not the only nation ramping up R&D while we rest on our laurels, seemingly attached to the groundless belief that the US is so ahead of other nations that we can operate on cruise control," observes Mary Woolley, president of advocacy group Research!America in Alexandria, Virginia.

The past decade has seen a drop in overall US research and development (R&D) funding of about 12% in real terms, say Matt Hourihan, director of the R&D Budget and Policy Program at the American Association for the Advancement of Science. Most of that budget decline hit defence-related R&D. "I think we will be treading water for at least a few years to come," he adds. The Obama administration has proposed near-level funding of US\$64.7 billion for basic and applied research in fiscal year 2015, and of US\$68.0 billion for developmental research.

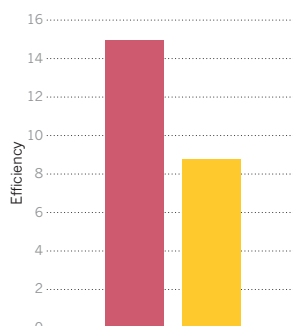
Life sciences are particularly strong in the United States. In 2013, the Nobel Prizes in

## NORTH AMERICA ANALYSIS

**Countries' weighted fractional count (WFC)**  
 The United States dominates the region and leads the world.

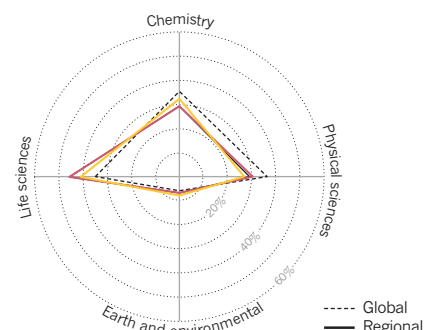


**Researcher efficiency**  
 WFC per 1,000 researchers<sup>1</sup>.



**Research strengths**

Both countries are above the global average for life sciences research<sup>2</sup>.



1. Source: UNESCO. 2. Subjects overlap, so the total for each country can be >100%.

Chemistry and in Physiology or Medicine both went to scientists based either wholly or partly in the United States. In the Nature Index, the country is also most dominant in the life sciences, where it accounts for just under half of the global WFC (See ‘Life science share’).

However, 2013 was a troubled year for US research, with federal sequester cuts in March, triggered by the failure of Congress to otherwise lower the budget deficit. These cuts hit science spending, for example slicing off about 5% of the NIH budget. Related turmoil effectively shut down most of the federal government in October, halting research at many labs. The NIH was forced to send 12,000 scientists home for “16 very, very long days,” says Lawrence Tabak, NIH principal deputy director. Uncertainty about a national commitment to science “casts a pall on young people who are considering a career in biomedical research”, he adds.

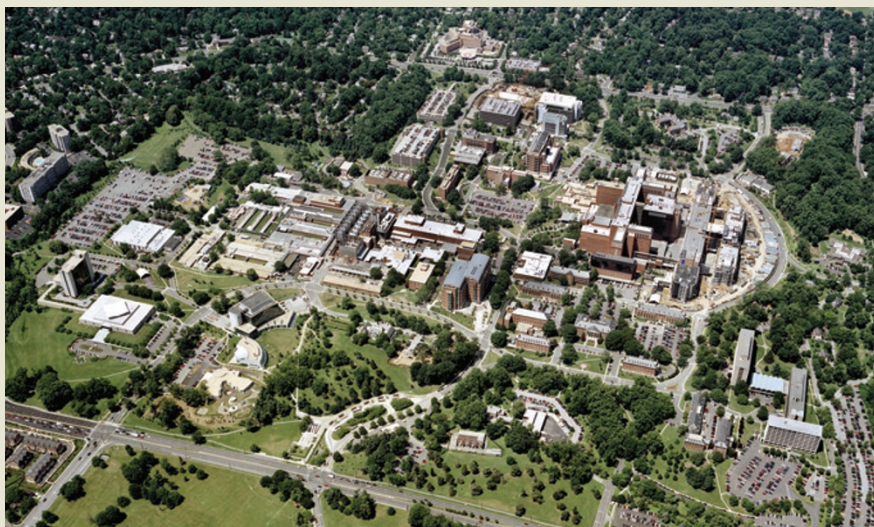
Overall spending has since crept up to around pre-sequester levels, but budget uncertainties continue. Another round of sequester cuts is scheduled for fiscal year 2016 unless federal deficit-reduction targets are met, says Hourihan.

**CANADA: GETTING DOWN TO BUSINESS**

Canada’s WFC of 1,483 belies its relatively small population of 35 million (just 2 million more than Morocco), and the country “continues to punch above its weight in global science,” according to Paul Dufour, an independent science and technology policy consultant based in Gatineau, Quebec. Its strength is “largely a function of the enormous expenditures since the mid-1990s in higher-education research,” he says. Annual spending on natural science and engineering research by academic institutions has more than tripled in real terms, from Can\$3 billion in 1996. (However, despite the long-term upwards trend, overall federal spending on science and technology from government, industry

**NATIONAL INSTITUTES OF HEALTH**

*Realigning for reductions*



NATIONAL CANCER INSTITUTE/SCIENCE PHOTO LIBRARY

The National Cancer Institute is the NIH’s biggest institute

The US National Institutes of Health (NIH) is the country’s largest civilian research agency, with an annual budget of around US\$30 billion. About 10% of the budget goes on intramural research, mostly at its headquarters in Bethesda, Maryland.

When *Science* declared cancer immunotherapy as its Breakthrough of the Year in 2013, one of the two types of immunotherapy honoured was adoptive T-cell therapy, a field in which NIH researcher Steven Rosenberg played a pioneering role. That was just one mark of excellence for the NIH’s intramural programme – the tenth largest contributor to high-quality scientific output in the Nature Index by WFC, and second to Harvard when just the life sciences are considered. However, much

of the NIH’s work covers clinical trials, and clinical journals are not yet included in the Nature Index.

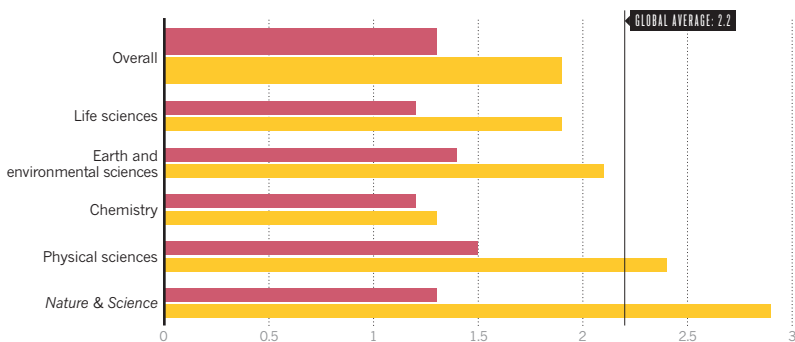
Overall, NIH published 35 papers in *Nature* and 25 in *Science* in 2013, together accounting for just over 7% of its output, with a combined WFC of 28. This places the NIH fifth in the index, just under Germany’s Max Planck Society, which had about €1.53 billion (US\$1.97 billion) in public funding that year.

“We’re seeing tremendous basic science opportunities,” says Lawrence Tabak, NIH principal deputy director. However, Tabak points out that NIH overall has lost about 20% of its purchasing power in the past decade. Tabak echoes the sentiments of other observers of US science: “We need to get on a more stable trajectory.”

United States Canada

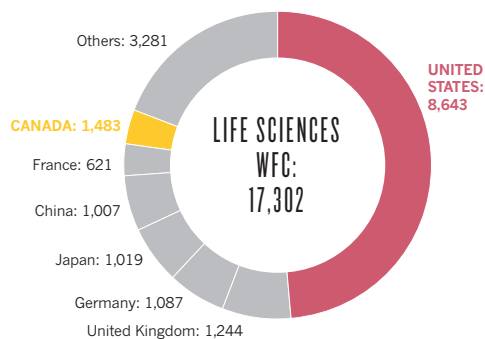
**Collaboration rate**

Dividing AC by FC gives a proxy for average number of collaborators per paper from outside the country.



**Life science share**

Nearly half of all life sciences research in the Nature Index was conducted by US scientists.





MJBS/THINKSTOCK



Life sciences are Harvard's strength

IT IS IN THE NATURE AND SCIENCE COUNT THAT HARVARD REALLY SHOWS ITS STRENGTH.

and academia has been heading south for several years.)

Canada spends about 1.9% of its gross domestic product (GDP) on R&D, a similar ratio to that of China and considerably less than that of the United States at 2.8%, according to estimates by Battelle Memorial Institute. R&D spending by industry and by national defence agencies, however, is much lower in Canada than in the other two countries.

Recently there has been a strong federal push to tie research more closely to business. One prominent example, Dufour notes, has been a retooling of the premiere lab, the National Research Council, to focus on business-led research. Also, "new funding going to universities has interesting clauses trying to target work closely to businesses," Dufour says.

A number of federal initiatives have strengthened research efforts. Since 1997, the Canada Foundation for Innovation programme and its partners have poured more than Can\$12 billion (about US\$11 billion) into new buildings, facilities and other research infrastructure. Beginning in 2000, the Canada Research Chairs programme has created about 2,000 research professorships, with an annual budget of about \$265 million.

Key areas of research such as quantum computing and neuroscience are supported by the related programme Canada Excellence Research Chairs, which allows Canadian universities to compete for leading international researchers. "Budgets and funding are limited, but the return on investment is worth it if Canada makes strategic investments in areas of global impact," says Feridun Hamdullahpur, president and vice-chancellor of the University of Waterloo and chair of the U15 Group of Canadian Research Universities.

The Canada Excellence Research Chairs programme seeks to maintain the country's long-standing success in attracting researchers from abroad. According to a 2014 report from The Council of Canadian Academies,

51% of individuals holding science, technology, engineering, and mathematics degrees in Canada are immigrants. (That's about twice the percentage of foreign-born college-educated scientists and engineers working in the United States, according to National Science Foundation estimates.)

THREE NORTH AMERICAN LEADERS

Three institutions exemplify the strengths of major North American academic organizations: the two US institutions that place highest in the Nature Index, Harvard University and Stanford University, and the top Canadian institution, the University of Toronto. The index reveals that these three have quite different research profiles.

Harvard has about 2,100 faculty members and its sponsored research funding totalled US\$821 million in 2013. Stanford employs roughly the same number of faculty, with a sponsored research budget of \$1.35 billion (including \$452 million for the SLAC National Accelerator Laboratory, which Stanford operates on behalf of the Department of Energy).

The University of Toronto, with a faculty of about 12,500, is the largest research organization in Canada. The university and its partner hospitals received sponsored research funding of about Can\$1.1 billion (US\$1.0 billion) for 2013. As a public institution, it has about 67,000 undergraduate students, an order of magnitude more than Harvard or Stanford.

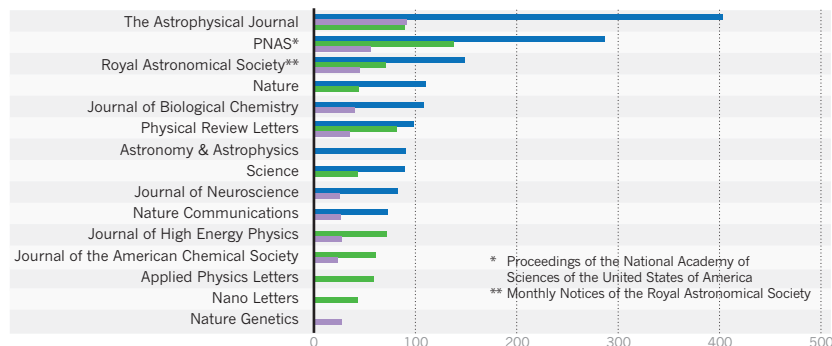
Posting a WFC of 852, Harvard comes in second among global research institutions, behind the gigantic Chinese Academy of Sciences with a WFC of 1,209. Stanford comes fifth with 553, and Toronto is 28th overall with 242.

Both Harvard and Toronto publish most in *The Astrophysical Journal*, with 403 papers from researchers at Harvard (representing 14% of all 2013 papers in this journal) and 91 from Toronto. There were also 89 papers from Stanford, although this Californian institution published most frequently in the

Harvard Stanford Toronto

Top ten journals

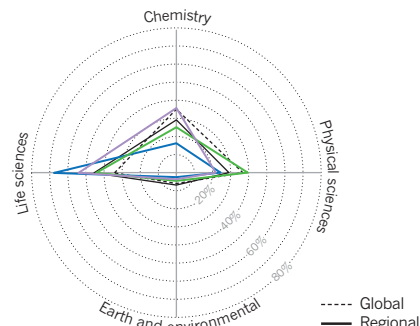
Astrophysics is strong for all universities. After that, Harvard's publications are mixed; Stanford shows preference for the physical science journals, whereas Toronto favours life sciences.



\* Proceedings of the National Academy of Sciences of the United States of America  
 \*\* Monthly Notices of the Royal Astronomical Society

Institutional subject spread

More than two-thirds of Harvard's output is in the life sciences!



1. Some subjects overlap, so total can be >100%

interdisciplinary journal *Proceedings of the National Academy of Sciences* (PNAS) (see ‘Top ten journals’). Nevertheless, the institution with the strongest slant towards physics overall is Stanford, with 39% of its output in this field. (see ‘Institutional subject spread’)

Stanford’s five top journals in the Nature Index are all in the physical sciences. The university hosts the SLAC Lab, which on its own achieved a WFC of 56. Among SLAC’s accomplishments was a *Nature* paper that made a significant step toward creating an electron accelerator on a chip. However, it is the Massachusetts Institute of Technology (MIT) that published more physical sciences papers than any other North American institute, with a WFC of 228 – that’s more than Stanford’s 215 and Harvard’s 195 (see physical science table, page S107).

“CANADA CONTINUES TO PUNCH ABOVE ITS WEIGHT IN GLOBAL SCIENCE.”

Earth and environmental sciences makes up only a small proportion of the total Nature Index papers, and all three institutions publish fewer than the global average in this field. The top North American institutions are two government agencies: NOAA and NASA (page S105). Stanford is fifteenth globally, but is in the process of expanding its Earth Sciences department — and in 2013 two of its faculty were given prestigious MacArthur Fellowship (“genius”) awards.

One of Stanford’s high-profile papers in this field was published in *Science*, and found that current climate change is happening an order of magnitude faster than at any other time in the past 65 million years.

All three institutions published most of their papers in the life sciences, particularly

Harvard where this subject accounted for more than two-thirds of its output. Indeed, Harvard is the leading institution in the Nature Index for life sciences (see life sciences table, page S104); this is the only subject where the Chinese Academy of Sciences is not top.

This achievement partly reflects the sheer size of Harvard Medical School, which has more than 10,000 academic appointments in affiliated teaching hospitals alone, compared to around 700 for Toronto and 600 for Stanford. Harvard’s interdisciplinary groups, such as the Harvard Stem Cell Initiative and Wyss Institute for Biologically Inspired Engineering, also did well in *Nature* and *Science*.

It is in this count where Harvard really shows its strength. In 2013 Harvard contributed to 199 papers in total in *Nature* and *Science*, (see ‘Nature and Science output’) accounting for 9% of the total Nature Index articles it contributed to, making it by far the global leader by this metric. In fact there are three US institutions in the top three *Nature* and *Science* list by WFC: Harvard is followed by MIT and then Stanford (see Nature and Science table, page S108). The University of Toronto published 34 papers in *Science* or *Nature*, representing 6% of its output in the index. All three North American universities are comfortably above the world average of just over 3%. (See ‘State analysis’.)

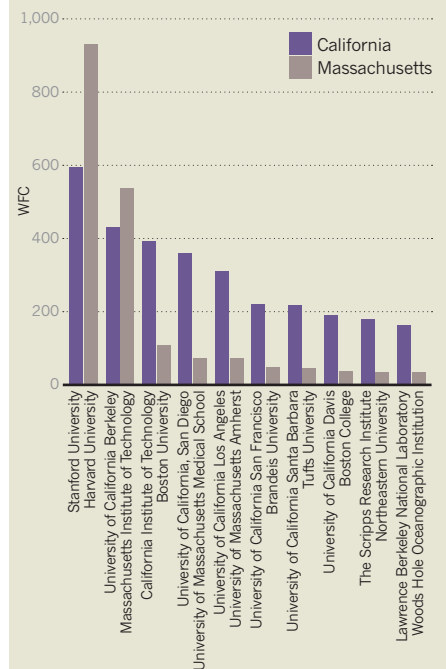
In terms of online attention (everything from Twitter to news articles) for scholarly papers, Altmetrics provides some interesting data. In this respect, Harvard has a higher visibility than the other two institutes. One of its papers from *Science*, “Poverty impedes cognitive function” (see ‘Harvard’s online visibility’), is in the top five papers of the year according to altmetric.com (as of 22 September 2014). However, it is a Stanford *Nature* paper, “Structural and molecular interrogation of intact biological systems”, about a way to make biological tissue transparent, that gained the highest score for papers from a single institution. ■

STATE ANALYSIS

Massachusetts v. California

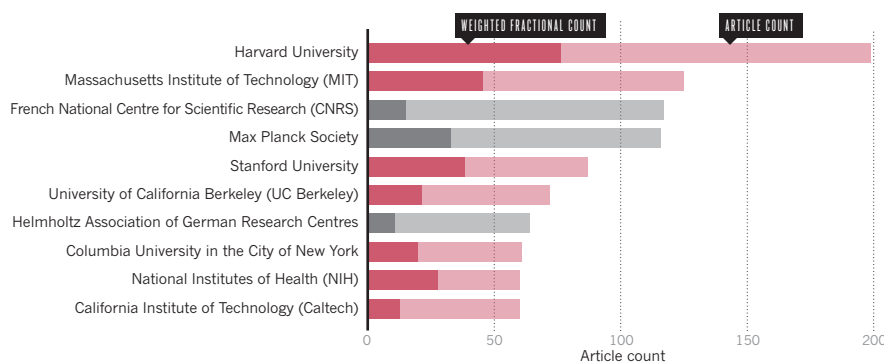
While Harvard might be dominant on an individual institution basis, it is Stanford’s home state of California that shows the most scientific muscle. In the Nature Index there are 159 research institutions in California that contribute to Nature Index papers (including 12 separate campuses of the University of California) compared to only 64 in Massachusetts. After Harvard and MIT there is a big drop-off for the northeastern state, whereas California’s top institutions are still delivering strong WFC scores down to the twentieth institution and beyond.

Harvard boosts its home state of Massachusetts, but California has a deeper research base.



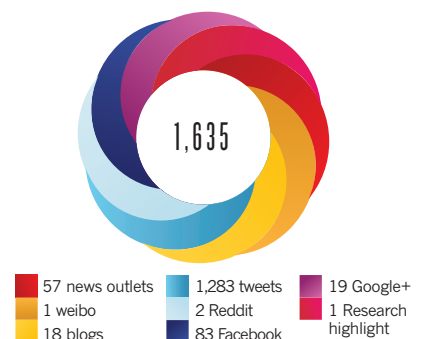
Top ten for Nature and Science

Harvard leads when just article count in these two highly selective journals are considered.



Harvard’s online visibility

Harvard’s most-shared paper by altmetric score is also one of the top-scoring papers<sup>1</sup> in all of *Science*.



1. DOI: Science 341/6149/976. Data taken from altmetrics.com on 22 Sept 2014.